GENERAL DYNAMICS | CONVAIR

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Material - Stainless Steel - Type 410, Casting

Effect of Surface Preparation on Adhesive Bond Strengths

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Abstract:

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Alloys (1)	Cleaner (2)	Bond Strength			
		R.T.	SS(3)	-67°F	300°F
7075-410	1	3190	4080	2110	2275
7075-410	2	3635	3690	2945	1620
2024-410	1	2690	3910	1690	1670
	2	3320	4050	2480	1560
7075-7075	1	4015	4155	1610	2145
2024-2024	1	3890	4165	2115	2265

(1) 7075-T6, 2024-T86 aluminum alloys, Type 410 stainless steel.

(2) 1, sulfuric acid-sodium dichromate cleaner; 2, hydrofluoric acid cleaner.

(3) Tested at room temperature after 30 days salt spray exposure.

Reference: Pearson, H., Picotte, G. L., Keller, E. E., "Aluminum to Stainless Steel Bond Tests," General Dynamics/Convair Report MP 57-603, San Diego, California, 30 December 1957 (Reference attached).

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A DIVISION OF GENERAL DYNAMICS CORPORATION
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STRUCTURES-MATERIALS LABORATORIES

REPORT 57-603
DATE 12-30-57
MODEL F-106A

TITLE

REPORT NO. 57-603
ALUMINUM TO 410 STAINLESS
STEEL BOND TESTS

MODEL: F-106A

CONTRACT: AF33(600) 30169

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ACCESS NO.

Title: MATERIAL - STAINLESS STEEL - TYPE 410, CASTING. EFFECT OF SURFACE PREPARATION ON ADHESIVE BOND STRENGTHS.

Authors: Pearson, H., Picotte, G. L., Keller, E. E.
Report No. 8926-127 Date: 30 December 1957
Contract: AF 33(600)-30169
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2, hydrofluoric acid cleaner.

(3) Tested at room temperature after 30 days salt spray exposure.

REPORT NO. 57-603
ALUMINUM TO 410 STAINLESS STEEL BOND TESTS

INTRODUCTION:

In accordance with a letter from AMC, substantiation of the stainless steel surface treatment described in paragraphs 3.2.2.4 and 3.2.2.5 of Convair Specification 8-01318 was deemed necessary. The relative effect of cleaning with sulfuric acid-sodium dichromate type solutions and of hydrofluoric acid cleaners on bond strength was desired. The stainless steel alloy to be tested was Type 410 in cast form.

OBJECT:

To evaluate present stainless steel cleaning methods on Type 410 cast stainless steel in accordance with Convair Specification 8-01318.

CONCLUSION:

Satisfactory results were obtained with both the sulfuric acid-sodium dichromate and hydrofluoric acid surface treatment systems. The hydrofluoric acid method specified in 3.2.2.5 is the better of the two systems in regards to bond strength.

RECOMMENDATION:

Some thought should be given to the necessary strength requirements before establishing a production line surface treatment system on this type steel. Even though slightly higher tensile shear values are obtained by the alternate cleaning method, it would be considerably more hazardous in operation. The use of boiling hydrofluoric acid in the cleaning procedure would necessitate the use of special cleaning tanks and severe safety precautions. Possibly the loss in bond strength could be sacrificed to allow for ease in handling.

DESCRIPTION OF SPECIMENS:

The specimens were of the lapped tensile shear type. One half of each test specimen was aluminum and the other half steel. The aluminum half specimens consisted of two types. These were .064" 7075-T6 clad and .064 2024-T86 bare aluminum alloys. They were cut and subsequently milled to one by four inch dimensions. These will hereafter be referred to as type "A" and type "B" aluminum respectively.

The steel half of specimens were cut from four F-106 rudder horns. It was found that by making some of the samples slightly less than the desired one by

DESCRIPTION OF SPECIMENS: (Continued)

four inch size, forty-one pieces .051" thick could be obtained. During the milling operation both sides of the specimens were given a 125 microinch finish.

A duplicate set of aluminum to aluminum specimens were prepared for control purposes.

TEST PROCEDURE:

The aluminum half of test specimens were cleaned with dichromate-sulfuric acid cleaning solution as set forth in paragraph 3.2.2.1 of Specification 8-01318, oven dried for 20 minutes at 175° F, allowed to cool to room temperature and primed with EC 1459, LOT 16H6S. The specimens were then air dried for 15 minutes at room temperature and precured 30 minutes in a circulating air oven at 280° F, preparatory for bonding.

The steel half of test specimens were divided into two groups. One group was cleaned in accordance with paragraph 3.2.2.4 of Specification 8-01318 and shall be referred to as type 1. The other group was cleaned by the method specified in paragraph 3.2.2.5 of Specification 8-01318 and shall be called type 2. Both sets of specimens were then dried and primed in the same manner as were the aluminum specimens described above.

A special jig, see Figure 1, was fabricated to hold the specimens in place during the bonding operation. This fixture maintained the overlap distance as well as the alignment of the two half specimens. All specimens were bonded with AF 31, LOT 24 adhesive at 350° F ± 10° F for 2 hours ± 5 minutes and at a pressure of 100 psi ± 5, according to the procedure set forth in Convair Specifications 8-01318 and 0-03007.

The bonded specimens were of four kinds; type "A" aluminum bonded to type 1 and 2 steel and type "B" aluminum bonded to type 1 and 2 steel. Hereafter in this report these test specimens will be referred to by the following designations; A_1, A_2, B_1, and B_2 respectively. Each type of specimen was tested as follows: room temperature, room temperature after thirty days exposure to salt spray, minus 67° F. and plus 300° F. The specimens subjected to salt spray exposure were tested within two hours after their removal from the environmental cabinet. The salt spray exposure was done in accordance with Specification QQ-M-151.

All testing was done on a Tinius Olsen testing machine with appropriate attachments.

RESULTS:

The results of tensile shear tests are recorded in Tables 1, 2, 3, and 4.

NOTE: Note; The 300° F tensile shear values given in Tables 1 and 2 are low due to a mechanical failure of the testing machine.

The data from which this report was prepared are recorded in Data Book No. 891.

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TABLE 1

7075-T6 CLAD ALUMINUM-TYPE 1 AND TYPE 2 STEEL

SPEC	TEST TEMP	WIDTH RED	LENGTH RED	LBS ULTIMATE	PSI ULTIMATE	FAILURE GAGE	FAILURE ADH	SPEC	TEST TEMP	WIDTH RED	LENGTH RED	LBS ULTIMATE	PSI ULTIMATE	FAILURE GAGE	FAILURE ADH
1A1	RT*	0.98	0.50	1270	2600	100	—	1A2	RT1	0.99	0.50	1895	3710	25	75
2A1	RT1	0.99	0.50	1565	3160	75	25	2A2	RT1	1.00	0.51	2090	3940	40	60
3A1	RT1	0.99	0.50	1560	3155	90	10	3A2	RT1	0.97	0.51	1905	3950	50	50
4A1	RT1	1.00	0.50	1960	3840	100	—	4A2	RT1	0.97	0.50	1520	3140	85	15
AVE					3190			AVE					3635		
5A1	RT	0.99	0.52	2280	4438	95	5	5A2	RT	1.00	0.52	2100	4038	90	10
6A1	RT	1.00	0.51	1825	3520	90	10	6A2	RT	1.00	0.52	1905	3660	65	35
7A1	RT	0.99	0.51	2205	4340	90	10	7A2	RT	0.98	0.51	1805	3610	95	5
8A1	RT	0.99	0.50	1945	3930	95	5	8A2	RT	1.00	0.53	1955	3690	50	50
AVE					4080			AVE					3750		
9A1	-67°F	1.00	0.51	1170	2280	100	-	9A2	-67°F	1.00	0.51	1400	2800	100	-
10A1	-67	1.00	0.51	1220	2380	100	-	10A2	-67	1.00	0.50	1310	2620	100	-
11A1	-67	1.00	0.50	1060	2120	100	-	11A2	-67	1.00	0.51	1665	3262	100	-
12A1	-67	1.00	0.50	780	1660	100	-	12A2	-67	1.00	0.51	1580	3100	100	-
AVE					2110			AVE					2945		
13A1	300°F	1.00	0.50	1135	2270	-	100	13A2	300°F	0.98	0.50	750	1530	-	100
14A1	300	1.00	0.50	1120	2240	-	100	14A2	300	0.97	0.50	730	1500	-	100
15A1	300	1.00	0.50	1245	2490	-	100	15A2	300	0.98	0.51	835	1670	-	100
16A1	300	1.00	0.50	1050	2100	-	100	16A2	300	1.00	0.51	915	1790	-	100
AVE					2275			AVE					1620		

*RT - 79°F - TYPICAL OF ALL

ADH - ADHESIVE FAILURE

COH - COHESIVE FAILURE

RT1 - TESTED AFTER SALT SPRAY EXPOSURE

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TABLE 2

2024-T86 BARE ALUMINUM - TYPE 1 AND TYPE 2 STEEL

SPEC	TEST TEMP	WIDTH OF BOND	LENGTH OF BOND	LBS ULTIMATE	PSI ULTIMATE	FAILURE ADH	FAILURE COH
1B.	RT$_1$	0.99	0.50	1235	2500	70	30
2B.	RT$_1$	1.00	0.51	1505	2950	60	40
3B.	RT$_1$	1.00	0.49	1360	2780	50	50
4B.	RT$_1$	1.00	0.48	1210	2520	100	-
AVE					2690		
5B.	RT	1.00	0.51	2040	4000	100	-
6B.	RT	1.00	0.51	1955	3830	90	10
7B.	RT	1.00	0.50	2000	4000	100	-
8B.	RT	0.99	0.50	1890	3820	100	-
AVE					3910		
9B.	-67°F	1.00	0.51	1145	2240	100	-
10B.	-67	1.00	0.48	700	1460	100	-
11B.	-67	1.00	0.48	780	1630	100	-
12B.	-67	0.98	0.52	730	1430	100	-
AVE					1690		
13B.	300°F	0.99	0.50	825	1670	-	100
14B.	300	1.00	0.50	885	1770	-	100
15B.	300	0.99	0.50	800	1620	-	100
16B.	300	0.97	0.50	780	1610	-	100
AVE					1670		

SPEC	TEST TEMP	WIDTH OF BOND	LENGTH OF BOND	LBS ULTIMATE	PSI ULTIMATE	FAILURE ADH	FAILURE COH
1B$_2$	RT$_1$	1.00	0.50	1545	3090	20	80
2B$_2$	RT$_1$	0.99	0.48	1240	2610	100	-
3B$_2$	RT$_1$	1.00	0.52	1960	3770	90	10
4B$_2$	RT$_1$	0.99	0.50	1730	3500	40	60
AVE					3320		
5B$_2$	RT	0.99	0.50	2060	4160	75	25
6B$_2$	RT	0.99	0.53	1985	3780	95	5
7B$_2$	RT	0.99	0.53	2060	3920	100	-
8B$_2$	RT	1.00	0.50	2170	4340	85	15
AVE					4050		
9B$_2$	-67°F	1.00	0.51	1605	3150	100	-
10B$_2$	-67	1.00	0.50	1215	2430	100	-
11B$_2$	-67	1.00	0.50	1105	2210	100	-
12B$_2$	-67	0.99	0.50	1230	2480	100	-
AVE					2555		
13B$_2$	300°F	0.98	0.48	790	1680	-	100
14B$_2$	300	1.00	0.50	815	1630	-	100
15B$_2$	300	1.00	0.50	820	1640	-	100
16B$_2$	300	0.97	0.50	620	1280	-	100
AVE					1560		

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TABLE 3

7075-T6 CLAD ALUMINUM CONTROL SPECIMENS

SPEC	TEST TEMP	WIDTH (AREA)	LENGTH (AREA)	LBS ULTIMATE	PSI ULTIMATE	FAILURE IN GAGE	FAILURE OUT OF GAGE
1A	RT	1.00	0.50	1920	3840	-	100
2A	RT	1.00	0.50	2005	4010	-	100
3A	RT	1.00	0.51	2115	4140	-	100
4A	RT	1.00	0.50	1920	3840	5	95
5A	RT	1.00	0.50	2045	4090	-	100
6A	RT	1.00	0.51	2170	4240	-	100
7A	RT	1.00	0.51	2155	4210	-	100
8A	RT	1.00	0.50	1985	3970	-	100
9A	RT	1.00	0.50	2005	4010	-	100
10A	RT	0.99	0.50	1825	3780	-	100
AVE					4015		
11A	RT	1.00	0.50	2005	4010	100	-
12A	RT	0.98	0.51	1995	3990	100	-
13A	RT	1.00	0.50	2170	4340	100	-
14A	RT	1.00	0.50	2180	4360	90	10
15A	RT	1.00	0.50	2170	4340	95	5
16A	RT	1.01	0.50	1840	3880	100	-
AVE					4155		

SPEC	TEST TEMP	WIDTH (AREA)	LENGTH (AREA)	LBS ULTIMATE	PSI ULTIMATE	FAILURE IN GAGE	FAILURE OUT OF GAGE
17A	-67°F	1.00	0.50	865	1730	100	-
18A	-67	1.00	0.49	860	1725	100	-
19A	-67	1.00	0.50	830	1660	100	-
20A	-67	1.00	0.50	960	1920	100	-
21A	-67	1.00	0.50	785	1570	100	-
22A	-67	1.00	0.50	600	1200	100	-
23A	-67	1.00	0.51	805	1595	100	-
24A	-67	1.00	0.50	760	1520	100	-
AVE					1610		
25A	300°F	1.00	0.49	960	1960	-	100
26A	300	1.00	0.50	1090	2180	-	100
27A	300	1.00	0.51	1165	2280	-	100
28A	300	1.00	0.49	955	1950	-	100
29A	300	1.00	0.50	1170	2340	-	100
30A	300	1.00	0.50	1080	2160	-	100
AVE					2145		

TABLE 4

2024-T86 BARE ALUMINUM CONTROL SPECIMENS

SPEC	TEST TEMP	WIDTH OF BOND	LENGTH OF BOND	LBS ULTIMATE	PSI ULTIMATE	FAILURE ADHESIVE	FAILURE COHESIVE
1B	RT	1.00	0.50	1920	3840	10	90
2B	RT	1.00	0.50	1895	3790	5	95
3B	RT	1.00	0.50	1985	3970	50	50
4B	RT	1.00	0.50	1905	3810	30	70
5B	RT	1.00	0.50	2035	4070	25	75
6B	RT	1.00	0.50	1850	3700	-	100
7B	RT	1.00	0.50	1890	3780	35	65
8B	RT	1.00	0.50	2030	4060	20	80
9B	RT	1.00	0.50	2020	4040	30	70
10B	RT	1.00	0.50	2015	4030	-	100
AVE					3890		
11B	RT	1.00	0.51	2130	4140	90	10
12B	RT	1.00	0.51	2185	4280	90	10
13B	RT	1.00	0.50	1910	3820	100	-
14B	RT	1.00	0.50	2080	4160	100	-
15B	RT	1.00	0.49	2020	4200	100	-
16B	RT	1.00	0.50	2185	4370	85	15
AVE					4165		

SPEC	TEST TEMP	WIDTH OF BOND	LENGTH OF BOND	LBS ULTIMATE	PSI ULTIMATE	FAILURE ADHESIVE	FAILURE COHESIVE
17B	-67°F	1.00	0.48	1025	2138	100	-
18B	-67	1.00	0.48	1030	2144	100	-
19B	-67	1.00	0 49	1585	3238	100	-
20B	-67	1.00	0.50	900	1800	100	-
21B	-67	1.00	0.50	1060	2120	100	-
22B	-67	1.00	0.50	1010	2020	100	-
23B	-67	1.00	0.49	705	1440	100	-
24B	-67	1.00	0.50	1005	2010	100	-
AVE					2115		
25B	300°F	1.00	0.50	1140	2280	-	100
26B	300	1.00	0.50	1095	2190	-	100
27B	300	1.00	0.52	1300	2500	-	100
28B	300	1.00	0.50	1125	2250	-	100
29B	300	1.00	0.50	1110	2220	-	100
30B	300	1.00	0.50	1075	2150	-	100
AVE					2265		

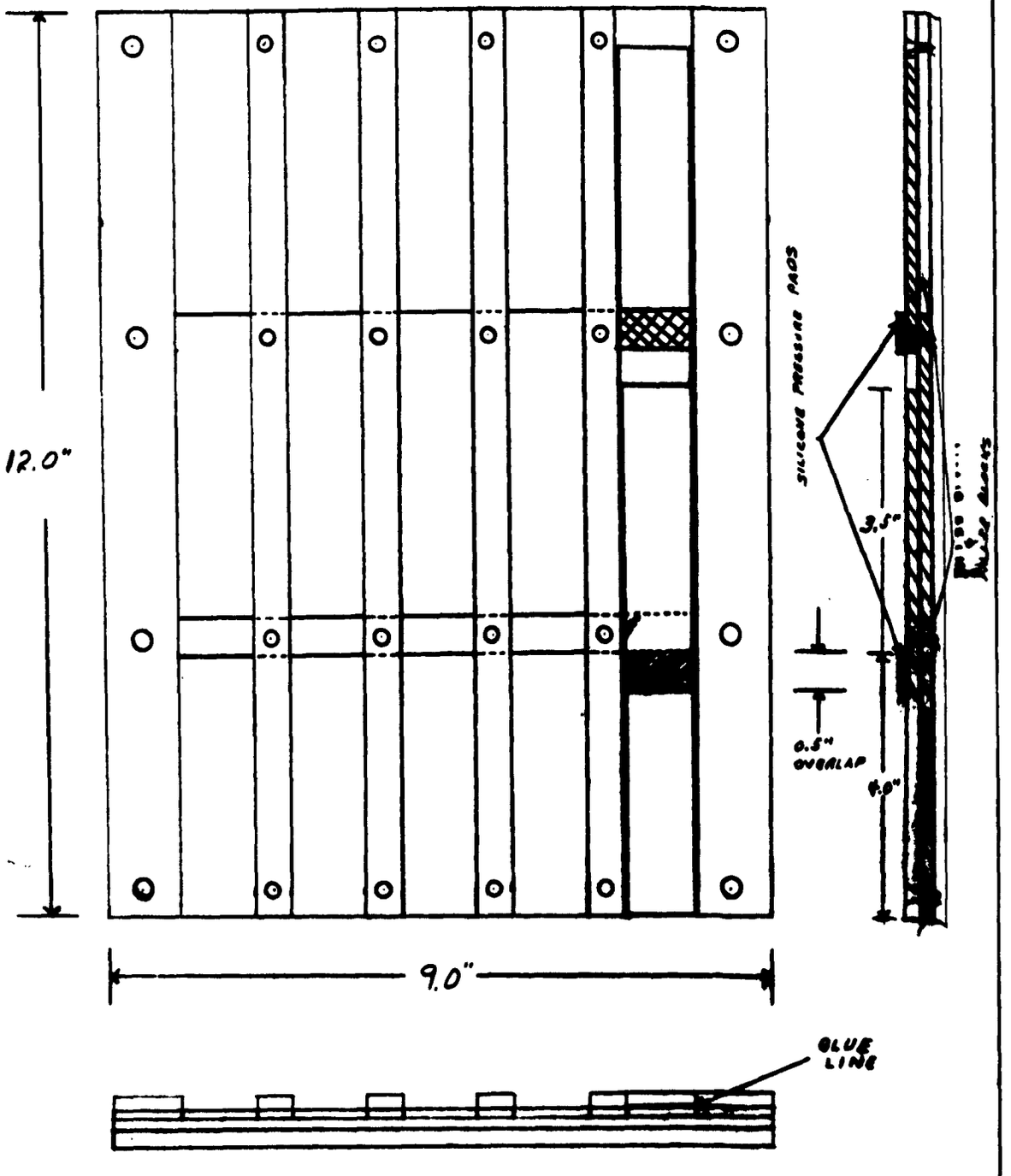

FIG. 1